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REPORT

ON THE

METEOROLOGY OF TORONTO:

BY

LIEUT.-COL. EDWARD SABINE, R.A., F.R.S.

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On the Meteorology of Toronto in Canada.

By Lieut.-Colonel EDWARD SABINE, *R.A., F.R.S.*

[A communication made to the Mathematical and Physical Section at the York Meeting, and directed to be printed entire amongst the Reports.]

THE subject which I am about to bring before the Section consists of a portion of the results of the meteorological observations which have been made at the magnetical and meteorological observatory at Toronto in Canada, in the first two years of its establishment. It is well known to the members of the Section, that in conformity with the recommendation made by this Association, the British Government has formed establishments in various parts of the globe, for the purpose of making magnetical and meteorological observations on a systematic plan, and has created a department for the reduction and publication of the observations. As the officer entrusted with the conduct of these operations, I regard it as not less a duty than a pleasure, to communicate, from time to time, at the meetings of the British Association, such of the arrangements, or of the observations themselves, or of the conclusions to which they may have led, as I may suppose may be interesting to its members. I have accordingly selected for the present occasion some portion of the results which the meteorological observations at Toronto, in 1841 and 1842, have yielded, when subjected to a full process of reduction, and carefully examined. I have preferred the meteorological to the magnetical observations, partly on account of the more popular character of the subject generally, and partly because the conclusions to which the meteorological observations have already conducted appear to possess a completeness and fullness not yet attained in magnetism. The observations, which will be treated of in this communication, were made at every second hour throughout the year, except on Sundays, Christmas day, and Good Friday. Subsequently to the period which will be now passed in review, they have been made hourly,

and the results of these may possibly be brought before the Section on a future occasion.

For the purpose of rendering this communication more interesting and more useful, I have compared the meteorological results obtained at Toronto with those obtained by M. Kreil at the magnetical and meteorological observatory at Prague in Bohemia*. It is frequently found that we gain more by such comparisons,—by the points of resemblance and points of difference, and by the analogies and contrasts which they bring to our notice,—than we do by a simple direct investigation.

Prague like Toronto is situated at a considerable distance from the ocean (between 300 and 400 miles) in the interior of a great continent, the latitude and elevation moreover not being very dissimilar. The agreement which will be shown in the leading features of their meteorology manifests that these features belong to a locality so circumstanced, whether the continent be Europe or America; whilst the minor differences point to climatological distinctions of a secondary order, important indeed to discuss from their bearing on the health and occupations of mankind, as well as in more purely scientific respects, but into which time will scarcely permit me to enter on the present occasion beyond a mere notice of some of the facts.

In all comparisons between places situated in Europe and in North America, there is one leading difference in respect to temperature which we must expect to find, which is doubtless familiar to all the members of the Section, viz. that in Europe we enjoy a climate of higher mean temperature in proportion to the latitude than is the case in America; in other words, that the isothermal lines descend into a lower latitude in America than they do in Europe. It would occupy far too much time to discuss, on the present occasion, the causes of this great climatological difference; they have been largely discussed by many eminent philosophers; but it may be well, before we proceed to further details, to notice briefly the *amount* of difference in this respect which is shown by the observations at Prague and Toronto.

The following statement exhibits the particulars of the latitude, elevation above the sea, and mean temperature of the two stations; as well as the correction of the difference of their mean temperatures on account of difference of elevation:—

Toronto, latitude.....	43° 39′	Elevation	330 feet.
Prague, „	50 05	„	582 „
Difference.....	6 26	Difference	252
Prague should be colder on account of its elevation .			0°·8 Fahr.
Mean temperature, Toronto 44°·4		Difference ...	4 ·3
„ Prague . 48 ·7 †			
Difference of temperature corrected for difference of elevation.....		Prague warmer	5 ·1

Whence it appears that Prague is 5°·1 warmer than Toronto, although its latitude is 6° 26′ more distant from the equator.

TEMPERATURE.

We will now proceed to the distribution of the mean temperature into the several hours of the day, and into the several months of the year; the first, forming the *diurnal* variation of the temperature, or that variation which has *a day* for its period; the second, the *annual* variation, or that variation which has *a year* for its period.

Diurnal Variation.—The diurnal variation is the well-known consequence

* Mag. und Met. Beobachtungen; Prag. 1839–1842. † Kreil, Jahrbuch für 1843.

of the earth's rotation on its axis. It is a single progression; having but one ascending and one descending branch, the turning points being a maximum early in the afternoon, and a minimum about sunrise. Each hourly mean in each year in the subjoined table is an average of about 311 observations, being one on each day, except Sundays, Good Friday and Christmas day. Each hourly mean of the two years is therefore an average of about 622 observations. The mean temperature of each year, or of all the hours on all the days of the year, rests on about 3732 observations; and the mean temperature of the two years on about 7464 observations. The very small amount of the differences which the table exhibits in the results at the several hours in 1841 and 1842, shows a probability that we have already determined the diurnal march of the temperature, (as far as it can be obtained by two hourly observations,) with a very near approximation to the truth*.

Mean Annual Temperature at every observation hour

	6 A.M.	8 A.M.	10 A.M.	Noon.	2 P.M.	4 P.M.	6 P.M.	8 P.M.	10 P.M.	Mid.	2 A.M.	4 A.M.	Mean.
Toronto. 1841...	39°0	42°4	46°2	48°8	50°4	50°3	48°1	44°0	42°0	40°7	39°5	38°8	44°2
1842...	39°8	42°9	46°5	49°1	50°7	50°8	48°2	44°2	42°3	41°0	40°2	39°6	44°6
Mean.	39°40	42°65	46°35	48°95	50°55	50°55	48°15	44°10	42°15	40°85	39°85	39°20	44°4

Temperature at the several observation hours higher (+) or lower (−) than the Mean Annual Temperature.

Toronto....	− 5°0	− 1°75	+ 1°95	+ 4°45	+ 6°15	+ 6°15	+ 3°75	− 0°3	− 1°25	− 3°55	− 4°55	− 5°2
Prague.....	− 4°7	− 2°6	+ 0°9	+ 3°8	+ 5°2	+ 5°1	+ 3°7	+ 0°8	− 1°1	− 2°3	− 3°4	− 4°4

Toronto proportionally colder (−) or warmer (+) than Prague at the several observation hours.

− 0°3	+ 0°85	+ 1°05	+ 0°65	+ 0°95	+ 1°05	+ 0°05	− 1°1	− 0°15	− 1°25	− 1°15	− 0°8

If we take the difference between the mean temperature at Toronto derived from all the observations (44°·4), and the mean of all the temperatures observed at each of the observation hours, we have the mean diurnal march of the thermometer as shown in the table, or how much the temperature amount is above or below its mean at each hour of observation.

In the line immediately beneath the diurnal march of the temperature at Toronto, is placed the diurnal march at Prague, by which means the general resemblance and the minor differences can be at once perceived by the eye.

These latter are further shown in the last line, which points out the hours when the temperature is proportionally warmer at Toronto than at Prague, which hours have a + sign before them, and those when it is proportionally colder, which are characterized by the − sign. It will be at once obvious that the climate at Toronto is proportionally warmer during the hours of the day, and colder during those of the night, than at Prague. Toronto being in a lower latitude and therefore nearer the sun, the sun's influence is proportionally greater during the hours of the day; but in the absence of the sun, the powerful causes which, in spite of the difference of latitude, depress the isothermal lines, show their unchecked influence in the proportionally lower temperature of the hours of the night. So strong indeed are those causes, that at no one hour of the twenty-four does the absolute temperature at Toronto rise to an equality with that of Prague.

* The building of the observatory at Toronto having been completed in September 1840, the observations now under notice commence with October 1840. The year 1841 in this communication is therefore more strictly the year which commences October 1, 1840, and ends September 30, 1841. In like manner 1842 commences with October 1, 1841, and ends with September 30, 1842.

The nights being proportionally colder and the days warmer than at Prague, the mean daily range of the thermometer is greater, being 9°·9 at Prague and 11°·35 at Toronto. The mean temperature of the 24 hours occurs earlier in the forenoon and earlier in the afternoon at Toronto than at Prague.

Annual Variation.—The next table exhibits the mean monthly temperatures in each month of 1841 and 1842, and their average. In a separate column is shown the amount by which the temperature in each month exceeds or falls short of the mean temperature of the year. This forms the annual variation of the temperature; it is, as is well known, the consequence of the earth's annual motion in its orbit, which regulates the order and succession of the seasons, and occasions a progression of temperature from a minimum in the midwinter to a maximum in the midsummer. This also is a single progression, having but one ascending and one descending branch. The annual variation of the temperature at Prague is placed by the side of that at Toronto, by which means the eye is at once enabled to judge of the general agreement and the minor differences; the latter are also shown more distinctly in the final column.

	Toronto.			Prague. Mean of 20 years.	The several months above (+) or below (−) the annual mean.		Toronto proportionally hotter (+) or colder (−) than Prague.
	1841.	1842.	Mean.		Toronto.	Prague.	
	°	°	°	°	°	°	°
January	25·6	27·8	26·7	26·9	−17·7	−21·8	+4·1
February.....	23·2	28·0	25·6	30·8	−18·8	−17·9	−0·9
March.....	28·1	36·2	32·1	38·6	−12·3	−10·1	−2·2
April	39·5	43·6	41·6	48·8	− 2·8	+ 0·1	−2·7
May	51·2	49·8	50·5	58·0	+ 6·1	+ 9·3	−3·2
June	66·1	56·6	61·3	64·6	+16·9	+15·9	+1·0
July	65·4	64·8	65·1	68·1	+20·7	+19·4	+1·3
August	64·5	65·7	65·1	66·7	+20·7	+18·0	+2·7
September.....	61·3	55·8	58·5	60·2	+14·1	+11·5	+2·6
October	44·7	41·9	43·3	50·1	− 1·1	+ 1·4	−2·5
November	35·7	35·3	35·5	38·8	− 8·9	− 9·9	+1·0
December	24·8	29·8	27·3	33·0	−17·1	−15·7	−1·4
Mean	44·2	44·6	44·4	48·7			

Difference between the hottest and coldest month.
Prague ..... 41°·2
Toronto..... 39°·5

In viewing the minor differences shown in the last column, we must not overlook that our numbers are based on two years only of observation, and that for an *annual* progression, a single year forms in fact but a single experiment. When we view the differences which some of the months present in the columns representing the observations in 1841 and 1842, we shall readily acknowledge that more than two years are required to give that approximation to a mean annual progression which the present state of science requires. There are, however, some features of difference which present such obvious characters of system that we may have reason to expect that the observations of a greater number of years will but make them more assured. Thus the spring months are all proportionally colder, and the summer months hotter, at Toronto than at Prague. There is also one remarkable difference, viz. in January, which is proportionally a colder month by above 4° at Prague than at Toronto; and from the magnitude of the amount, it wears the aspect of a permanent climatological difference. Now it is well known that in the month

of January the wind from the east and north-east prevails in Europe, bringing with it our severest winter cold. This feature has not a parallel in North America, where the cold of winter is more equably distributed. It would occupy too much time to discuss the cause of this peculiarity in the European climate; and I must content myself with referring generally to M. Dove's elaborate work on the distribution of temperature; a work which cannot fail to impress the reader strongly with the value of the conclusions to be derived from long-continued series of observations subjected to a laborious and persevering study. It is a curious result from this excess of cold in Europe in January, that notwithstanding the greater proportional warmth in summer and cold in spring at Toronto, the extreme difference, or that between the coldest and the warmest month of the year, is absolutely greater at Prague than at Toronto, being 41°·2 at Prague and 39°·5 at Toronto.

It is a consequence of the minor differences already pointed out, that a temperature equal to that of the mean temperature of the year occurs later in spring and earlier in autumn at Toronto than at Prague; and that the temperature is higher than the mean of the year during seven months at Prague, whilst at Toronto it is only so during five months.

I have inserted in the next table the mean *range* of the thermometer during three years at Toronto and at Prague. It must be understood that the maximum of each month inserted in this table is the *mean* maximum during three years; viz. March 1840 to March 1843 at Toronto; July 1839 to July 1842 at Prague; and the same is to be understood of the minimum: the range is consequently a *mean* range during three years, and is of course exceeded by the range in individual years.

Range of the Temperature in different Months.

	Toronto (3 years).			Prague (3 years).		
	Max.	Min.	Range.	Max.	Min.	Range.
	°	°	°	°	°	°
Jauuary	+47·3	+ 1·8	45·5	+46·8	+ 4·0	42·8
February.....	+42·7	− 1·0	43·7	+43·9	+ 1·6	42·3
March.....	+59·1	+ 7·0	52·0	+54·8	+13·8	41·0
April	+72·3	+23·0	49·3	+72·6	+29·1	43·5
May	+75·7	+29·5	46·2	+83·5	+40·0	43·5
June	+82·3	+37·2	45·1	+88·0	+47·0	41·0
July	+85·5	+45·1	40·4	+92·0	+50·6	41·4
August	+81·8	+47·0	34·8	+84·0	+48·4	35·6
September	+78·2	+32·0	46·2	+82·5	+40·2	42·3
October	+65·6	+25·5	40·1	+69·8	+31·4	38·4
November	+57·6	+12·7	44·9	+59·5	+29·5	30·0
December	+42·6	+ 3·7	39·0	+47·0	+12·4	34·6
	Mean range ...		43·9	Mean range ...		39·7
Toronto { Highest, June 29, 1841		+91·7		Prague { Highest, July 18, 1841		+97·8
Toronto { Lowest, Feb. 16, 1842		− 8·2*		Prague { Lowest, Dec. 15, 1840		− 7·0
	Range ...		99·9		Range ...	104·8

* The thermometer ranged much lower in January 1840, before the commencement of the series under notice, viz.—

January 2nd	− 17·5	January 15th	− 8·5
,, 3rd	− 9·2	,, 16th	− 15·0
,, 4th	− 10·0	,, 17th	− 19·2 lowest observation.

Here also the general character shown by the comparison of the two stations is that of very close resemblance, while the minor differences also stand out prominently. The greater variation to which the temperature is subject at Toronto in March and April is very obvious in the column of range; as is also the small amount of the variation in the month of November at Prague. The mean monthly range deduced from the twelve months is 43°·9 at Toronto, and 39°·7 at Prague; a considerable amount of difference, and which marks the greater general vicissitude of the climate of Toronto: still it is deserving of notice that Prague is occasionally liable to fully as great, and (during these three years at least) even greater extremes of temperature than Toronto, as is shown by the memorandum at the foot of the table; it is indeed curious to remark how very nearly the stations approach each other in the extreme amount of their thermometrical range. July and August are the only months in which during three years the observations at Toronto never show a temperature of the air so low as the freezing point. At Prague there are five months, viz. from May to September inclusive, in which during the three years the temperature was never observed so low as 32°.

If we seek in the old continent a station most nearly isothermal with Toronto, we must refer to a latitude considerably higher than Prague. The station in M. Mahlmann's list (Dove, Repertorium, b. 4, and Humboldt, Asie Centrale, tom. 3.), which most nearly resembles it in the mean temperature of the different seasons, as well as in that of the whole year, is Wexiö in Sweden, in latitude 56° 53′, and height above the sea 450 Parisian feet. Toronto is in 43° 39′, and height above the sea 330 English feet. The mean temperatures are—

	Spring.	Summer.	Autumn.	Winter.	Annual.	Coldest month.	Warmest month.
	°	°	°	°	°	°	°
Toronto	41·4	63·8	45·8	26·5	44·4	25·6	65·1
Wexiö	41·5	63·8	44·8	27;8	44·5	27·0	66·0

Aqueous Vapour.

I proceed to consider the elastic force or tension of the aqueous vapour contained in the atmosphere, and the degree of humidity produced by it, together with the diurnal and annual variations of these phænomena.

The elastic force of the vapour is considered to be one of the constituents of the pressure upon the surface of the mercury in the cistern of the barometer, which, conjointly with the other and much larger constituent, viz. the pressure of the gaseous atmosphere, produces what in common parlance is called the *pressure of the atmosphere*, measured by the height of the mercurial column in the barometer. Although we have no instrument by which we can measure the gaseous pressure independently of that of the aqueous vapour, we possess in Daniell's hygrometer, and in the wet and dry thermometers, the means of ascertaining the aqueous pressure at any instant independently of the gaseous pressure; and therefore, by the combination of the barometer and of the wet and dry thermometers (or of the hygrometer before mentioned), we should be able to obtain separately the pressure due to each constituent, and the annual and diurnal variations of both. It will be understood, therefore, that when the "tension of the vapour" is here mentioned, it expresses also the pressure on the barometer produced by the elastic force of the vapour present in the air.

The scale in which the humidity of the air is expressed is the simple natural scale in which air at its maximum of humidity (*i. e.* when it is satu-

rated with vapour) is reckoned as = 100; and air absolutely deprived of moisture as = 0: the intermediate degrees are given by the fraction

$$\frac{100 \times \text{actual tension of vapour,}}{\text{tension required for the saturation of the air at its existing temperature.}}$$

Thus if the air at any temperature whatsoever contains vapour of half the tension which it would contain if saturated, the degree is 50; if three-fourths, then 75; and so forth.

Air of a higher temperature is capable of containing a greater quantity of vapour than air of less temperature; but it is the proportion of what it *does* contain to what it would contain if saturated, which constitutes the measure of its dryness or humidity.

The capacity of the air to contain moisture being determined by its temperature, it was to be expected that an intimate connexion and dependence would be found to exist between the annual and diurnal variations of the vapour and of the temperature. I shall proceed to show how distinctly and fully this connexion is exhibited by the observations at Toronto. We will commence with the humidity.

Diurnal Variation.—The degree of humidity at the several observation hours exhibits, as in the case of the temperature, a simple progression of one ascending and one descending branch, having its turning points the same as those of the temperature, namely, a maximum at or near the coldest, and a minimum at or near the hottest hours of the day; the progression is inverse, but is in harmony with that of the temperature.

Mean degree of Humidity at Toronto at the several Observation Hours.

	6A.M.	8A.M.	10A.M.	Noon.	2P.M.	4P.M.	6P.M.	8P.M.	10P.M.	Mid.	2A.M.	4A.M.	Mean.
1841...	88	83	77	73	70	69	72	79	82	84	85	86	79
1842...	86	81	73	70	68	67	71	78	81	82	84	84	77
Mean.	87	82	75	71·5	69	68	71·5	78·5	81·5	83	84·5	85	78

The accord of the two years' observations is remarkably satisfactory; they unite in showing that in the average state of the atmosphere at Toronto, the air is charged with between three-fourths and four-fifths (or more exactly with 78 parts in 100) of the vapour required for its saturation.

When we proceed to the mean tension of the vapour at the several observation hours, we perceive an accord with the march of the temperature fully as striking; one ascending, one descending branch;—the turning points in obvious dependence,—and the march harmonious; in this case the progression is direct, in relation to that of the temperature,—as it was inverse in the case of the humidity.

Mean Tension of the Vapour at the several Observation Hours.

	6A.M.	8A.M.	10A.M.	Noon.	2P.M.	4P.M.	6P.M.	8P.M.	10P.M.	Mid.	2A.M.	4A.M.	Mean.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1841...	·249	·268	·282	·293	·296	·287	·276	·264	·254	·251	·243	·240	·267
1842...	·234	·251	·259	·271	·275	·273	·263	·250	·245	·236	·233	·229	·252
Mean.	·242	·260	·270	·282	·285	·280	·269	·257	·250	·243	·238	·234	·259

The direct evidence of connexion and dependence exhibited in the diurnal march of the vapour and temperature at Toronto is the more deserving of our notice, because in many climates, this connexion, though it always exists,

is partly obscured by other less direct influences of the temperature. Thus at Trevandrum, in the East Indies, where the zeal of our indefatigable associate Mr. Caldecott, Director of the Magnetical and Meteorological Observatory established by His Highness the Rajah of Travancore, has already accumulated, reduced, and transmitted to England five years of hourly observations with the wet and dry thermometers, the maximum and minimum of the tension are found to occur within three hours of each other; the minimum coinciding with the coldest hour, viz. at 6 A.M.; but the maximum occurring at 9 in the forenoon. This may possibly be a consequence of the sea breeze, which springs up as the sun gains power, and as the earth warmed by the solar rays heats the air in contact with itself and causes it to rise, occasioning an inpouring of the air from over the surface of the ocean. The sea breeze brings an influx of fresh air charged with vapour; the air in its turn is heated and ascends, but the vapour is subject to a different law; and though a portion of it is doubtless rapidly conveyed upwards by the ascending current, it is probably the accumulation below which causes an immediate rapid rise in the tension of the vapour, making its maximum to occur at a very early hour. The few facts which are yet known regarding the diurnal march of the vapour in different parts of the globe, present many phænomena of this nature, which at first sight appear inconsistent with the dependence of the progression of the vapour on that of the temperature; but which, when duly explained, will doubtless be found directly or indirectly in accordance with it. The knowledge of the phænomena of the vapour in different climates and under different circumstances (such as in insular, littoral, or continental situations, &c.), with the explanation of the various peculiarities which they present, will form hereafter a very interesting and beautiful chapter in the physical history of the globe.

Annual Variation.—We will now proceed to the mean *monthly* humidity and mean *monthly* tension exhibited in the following tables:—

Mean Monthly Humidity.

	Toronto.			Greater (+) or less (−) than the annual mean.
	1841.	1842.	Mean.	
Jan.....	87	81	84	+ 6·0
Feb.....	80	84	82	+ 4·0
March .	79	76	77·5	− 0·5
April ...	70	71	70·5	− 7·5
May.....	67	64	65·5	− 12·5
June	72	76	74	− 4·0
July	74	74	74	− 4·0
Aug.....	81	79	80	+ 2·5
Sept. ...	83	78	80·5	+ 3·0
Oct. ...	84	78	80·5	+ 3·0
Nov.....	86	81	83·5	+ 5·5
Dec.....	84	86	85	+ 7·0
Mean....	79	77	78	

Mean Monthly Tension.

	Toronto.			Greater (+) or less (−) than the annual mean.
	1841.	1842.	Mean	
	In.	In.	In.	
Jan. ...	·135	·130	·132	− ·127
Feb. ...	·107	·138	·123	− ·136
March..	·131	·162	·146	− ·113
April ...	·173	·199	·186	− ·073
May	·259	·227	·243	− ·016
June ...	·452	·347	·399	+ ·140
July	·449	·438	·443	+ ·184
Aug. ...	·482	·491	·486	+ ·227
Sept. ...	·453	·351	·402	+ ·143
Oct.....	·254	·210	·232	− ·027
Nov. ...	·185	·173	·179	− ·080
Dec.....	·122	·153	·138	− ·161
	·267	·251	·259	

We perceive by the table in which the mean monthly humidity is shown, that the months from March to July are drier than the average of the year, and that the remaining months are more humid than the average. The drier months are those in which the temperature of the air is rising; the most humid those in which the temperature is either falling or nearly stationary. When the temperature is rising the warmth increases more rapidly than the air re-

ceives the addition to its vapour required to maintain an equal degree of humidity, and the air becomes in consequence drier. This is even the case in the neighbourhood of extensive lakes, as at Toronto. May is the driest and December the most humid month in the year: and this is also stated to be the case in Europe.

When we turn to the table in which the mean monthly tension of the vapour is shown, we see most distinctly marked the connexion between the temperature and the vapour pressure, and the dependence of the one upon the other; we see a simple progression, the turning points being the same as those of the temperature, and a march as harmonious as we are perhaps entitled to expect from observations of only two years' continuance.

I shall reserve what further I may have to say in regard to the *range* of the vapour-pressure in different months, until we have before us the other constituent of the barometric pressure, viz. the gaseous atmosphere, to which I now proceed.

Atmospheric Pressure.

Toronto.	6 A.M.	8 A.M.	10 A.M.	Noon.	2 P.M.	4 P.M.	6 P.M.	8 P.M.	10 P.M.	Mid.	2 A.M.	4 A.M.	Mean.
Mean bar. Pressure.. 29 inch. + (1841.	·624	·637	·638	·616	·595	·591	·598	·609	·613	·607	·606	·610	·612
1842.	·613	·628	·631	·612	·594	·590	·595	·602	·603	·596	·593	·595	·604
Mean.	·618	·632	·634	·614	·594	·590	·596	·605	·608	·601	·600	·602	·608
Deduct pressure of the vapour..	·242	·260	·270	·282	·285	·280	·269	·257	·250	·243	·238	·234	·259
Press. of the gaseous atmosph. 29 inches + ..	·376	·372	·364	·332	·309	·310	·327	·348	·358	·358	·362	·368	·349
Pressure at each hour greater (+) or less (−) than the mean annual pressure	+·027	+·023	+·015	−·017	−·040	−·039	−·022	−·001	+·009	+·009	+·013	+·019	

Diurnal Variation.—The first two lines of this table exhibit the mean monthly pressure on the mercurial column at Toronto at the several observation hours of 1840 and 1841,—the mean of the two years is shown in the third line. The close accord of the mean pressure at the same hours in each of the two years is a very satisfactory testimony of the confidence to which these barometrical results are entitled: the mean at each hour of each year represents about 311 observations; consequently in the two years the mean at each observation hour represents about 622 observations, the mean of all the hours in the one year 3732 observations, and in the two years 7464 observations.

The diurnal march of the barometer may consequently be regarded as a very near approximation to the truth. The diurnal march of the vapour pressure is obtained by an equal number of observations, and may therefore also be viewed as a very near approximation to the facts of nature. By deducting the vapour pressure from the whole barometric pressure at each observation hour, we should obtain the daily march of the gaseous atmosphere. This is shown in the fifth line of figures in the table; and by taking the difference between the last column, (*i. e.* between the mean gaseous pressure at all the observation hours in the two years,) and the pressure at each hour, we obtain the amount by which the pressure is greater or less at each observation hour than the mean general pressure at all the hours.

On first casting our eyes (in the last line of the preceding table) on this representation of the diurnal variation of the gaseous atmosphere, freed from the complication which its combination with the vapour pressure produces

in the indications of the barometer, we cannot fail to be immediately struck with the very close correspondence of the diurnal march before our eyes with that of the temperature which we have already examined. The maximum of pressure is at 6 A.M.; the minimum at 2 P.M. The progressions take place in the opposite or inverse sense to each other, but they are remarkably harmonious, and leave no doubt of a mutual connexion, and of the dependence either of the one on the other, or of both on a common cause.

An explanation of this connexion, which presents itself to the mind as soon as the facts are clearly perceived, may be thus stated :—As the temperature of the day increases, the earth becomes warmed and imparts heat to the air in contact with it, and causes it to ascend. The column of air over the place of observation thus warmed rises, and a portion of it diffuses itself, in the higher regions of the atmosphere, over adjacent spaces where the temperature at the surface of the earth is less. Hence the statical pressure of the column is diminished. On the other hand, as the temperature falls, the column contracts, and receives in its turn a portion of air which passes over in the higher regions from spaces where a higher temperature prevails; and thus the statical pressure is augmented.

This explanation is merely the extension to the particular case of the diurnal variation, of principles which have long been familiar to meteorologists in accounting for various other atmospherical phænomena, such for example as monsoons, and land and sea breezes. To make the parallel complete, it should be shown that, when the temperature rises, an influx of air takes place towards the lower part of the column, proportioned to the ascending current, and tending to replace the air which is thus removed. The observations which will be cited in the sequel of this communication will show that such is precisely the fact at Toronto. The force of the wind, taken without reference to its direction, has also its diurnal variation, corresponding in all respects with the diurnal march of the temperature and of the gaseous pressure; being a minimum at 6 A.M., and a maximum at 2 P.M.—increasing with the augmentation of the temperature, and decreasing with its diminution. The air which thus flows in, becoming warmed, pursues in its turn the course of the ascending current. We have thus the double evidence of the existence of this current,—1st, in the diminution of pressure, showing the outpouring at one extremity; and 2nd, in the increased force of the wind, showing the inpouring at the other extremity. As the temperature keeps *continually* rising, both the demand for and the supply of fresh inflowing air progressively increase. The diminution which the gaseous pressure continues to undergo as long as the temperature continues to rise, shows, as we might naturally expect, that the supply is continually somewhat in arrear of the demand.

The diminution of the gaseous pressure and increase in the force of the wind being consequent on the rise of the temperature, the turning points of the two former phænomena might be expected to occur somewhat later than the instant of minimum temperature; and this appears by the tables to be the case, but will probably be more clearly shown when the hourly observations shall come under review.

Annual Variation.—Let us now proceed to the mean pressure of the gaseous atmosphere in each *month* of the year, and its consequent *annual* variation. These are shown in the following table :—

MEAN MONTHLY PRESSURE.

	Toronto.						Prague.	
	Barometer.			Vapour.	Gaseous pressure.	Gaseous pressure in each month greater (+) or less (−) than the mean annual pressure.	Gaseous pressure.	Gaseous pressure in each month greater (+) or less (−) than the mean pressure.
	1841.	1842.	Mean.					
January	29·664	29·508	29·586	·132	29·454	+·105	29·213	+·194
February.....	·489	·548	·518	·122	·396	+·047	29·227	+·208
March.....	·657	·638	·647	·146	·501	+·152	29·089	+·070
April	·621	·548	·584	·186	·398	+·049	28·973	−·046
May	·545	·586	·565	·243	·322	−·027	28·923	−·096
June	·543	·585	·564	·399	·165	−·184	28·898	−·121
July.....	·620	·655	·637	·443	·194	−·155	28·861	−·158
August	·698	·712	·705	·486	·219	−·130	28·882	−·137
September ...	·606	·662	·634	·402	·232	−·117	28·912	−·107
October	·636	·613	·639	·232	·407	+·058	29·045	+·026
November ...	·615	·568	·592	·179	·413	+·064	29·047	+·028
December ...	·652	·597	·625	·137	·488	+·139	29·163	+·144
Mean	29·612	29·604	29·608	·259	29·349		29·019	

In turning our attention to the column which exhibits the excess or defect of the mean monthly pressure on the mean of all the months, we at once perceive another illustration of the principle which has been just stated. We find the pressure of the gaseous atmosphere diminished in the summer months and augmented in the winter months. The general dependence on the march of the temperature is manifest; and it must remain for the additional evidence which will be produced by the observations of subsequent years, to determine, whether the minor deviations from a perfectly harmonious march are mere accidental differences, which a wider observation basis will cause to disappear, or whether they may not point to some other periodical influence (possibly of the temperature also, but of a less direct nature) which is as yet unrecognized*.

I will now ask the Section to turn its attention for a moment to the column which presents the mean height of the *barometer* in each month of the year. It is curious to observe how completely the annual march of the gaseous atmosphere is masked in the barometer by its combination with the vapour pressure, both being measured in one by the mercurial column; the increase of temperature, which causes the gaseous pressure to diminish, occasions the increase of the vapour, and *vice versâ*; and so nearly are these two opposite effects of the one cause balanced at Toronto, that the height of the barometer remains very nearly the same in every month of the year; or at least, shows no trace whatsoever of an annual period.

The principle which has been thus adduced for the purpose of explaining the annual and diurnal march of the atmospheric pressure should be ge-

* The very few meteorological registers, which have been maintained with proper care for several years together in Europe, are stated to afford very decided indications of the existence of other fluctuations besides the annual and diurnal variations, which apparently do not proceed from merely local causes, but recur regularly at stated periods of the year, and are recognisable simultaneously over widely extended spaces, such for example as a considerable portion of an entire continent. How far the high pressure of the month of March at Toronto may be a phænomenon of this class it may perhaps take some years to decide. It is of very marked character, and is shown decidedly in both years. As I have already remarked, each year is but a single experiment in investigations of annual phænomena.

neral in its application. I have inserted in the table the gaseous pressure at Prague, as it is given by M. Kreil in his 'Jahrbuch' for 1843, from the observations of three years. The march of the vapour, as far as it has yet been determined at Prague, does not present a curve agreeing quite so satisfactorily with that of the temperature as we have been able to deduce at Toronto: whether this arises from disturbing influences in nature (such possibly as indirect influences of temperature), or whether it will disappear by longer-continued observation, cannot be yet anticipated. What is still uncertain, however, at Prague, is not of magnitude sufficient to obscure the dependence of the annual progression of the gaseous pressure on that of the temperature. The measure of agreement in this respect at the two stations cannot be viewed otherwise than as highly interesting and satisfactory. Mean quantities derived from a greater number of years will in all probability show even a closer accordance.

We will now revert to the maximum, minimum and range of the vapour pressure in the several months of the year, for the purpose of showing that its variations are such, as to seem to claim a greater attention than they have hitherto received, at the hands of those who are engaged in investigating the non-periodic fluctuations of the atmosphere, by the comparison of observed barometrical heights. In the next table we have the maximum, minimum, and range of the vapour pressure at Toronto, taken from the mean of two years. By thus exhibiting the mean quantities only of the two years of observation, extremes are of course somewhat moderated; but, on the other hand, there is the advantage that the numbers are probably a more faithful representation of what may be expected in ordinary course.

Range of the Barometer.			Maximum, Minimum, and Range of the Tension of Vapour.					
			Toronto—Mean of 2 years.			Prague—Mean of 2 years.		
	Toronto.	Prague.	Max.	Min.	Range.	Max.	Min.	Range.
	in.	in.	in.	in.	in.	in.	in.	in.
January	1·335	1·364	·221	·050	·171	·306	·051	·255
February.....	1·221	1·156	·262	·050	·212	·238	·052	·186
March.....	1·275	1·158	·350	·045	·285	·278	·067	·211
April	1·190	0·864	·385	·085	·300	·406	·149	·257
May	0·846	0·881	·532	·105	·427	·555	·163	·392
June	0·623	0·873	·709	·143	·566	·659	·222	·437
July.....	0·696	0·593	·775	·202	·573	·662	·245	·417
August	0·656	0·647	·762	·262	·498	·556	·257	·299
September	0·754	0·755	·727	·158	·569	·567	·217	·350
October	0·934	0·829	·487	·096	·391	·447	·124	·323
November	0·945	1·036	·375	·066	·309	·414	·138	·276
December	1·527	1·222	·263	·048	·215	·300	·058	·242
Mean	1·000	0·950	·486	·109	·377	·449	·145	·304

We here perceive that the mean monthly range of the tension of the vapour falls little short of four-tenths of an inch; and that in the summer months of June, July, August, and September, when it is greatest, it is very little less than the whole range of the barometer in the same months. Winter is the season for the great fluctuations of the barometer; summer for those of the vapour pressure. If, as is believed by many modern meteorologists, the fluctuations of the vapour pressure affect the barometer to their whole extent, then the fluctuations of the gaseous atmosphere at Toronto approach

much nearer to an equality in the two seasons of summer and winter, than do those of the barometer. A north-west wind at Toronto is usually accompanied by a rise in the barometer and a fall in the temperature with a diminution in the tension of vapour; and a south or south-east wind, by a fall in the barometer and a rise in the thermometer with an increased tension of vapour. In a change from one of these winds to the other, consequently, the alteration of the gaseous pressure would be greater than that of the barometric pressure, which is partially counteracted by the accompanying change in the elastic force of the vapour: and as already noticed, the fluctuations in the vapour pressure are very considerable in summer. I have selected some remarkable instances in a single year, 1841, which are as follows:—

Variations of Vapour Pressure in 1841.

	d.	h.		d.	h.		
Between May	30	16	and June	5	4	under 6 days	0·594
„ June	11	0	„ June	15	10	„ 5 „	0·503
„ June	30	2	„ July	2	6	„ 3 „	0·610
„ July	2	6	„ July	5	4	„ 3 „	0·465
„ July	23	4	„ July	25	16	„ 3 „	0·500
„ Aug.	18	2	„ Aug.	23	14	„ 6 „	0·496

If the principles are correct, of which we have here traced a portion of the consequences, barometrical observations generally must lose an essential part of their value when unaccompanied by hygrometrical observations, by means of which the pressures of the air and vapour may be separated. Whenever such complete observations are made, *i.e.* hygrometric as well as barometric, the tension of vapour should be computed on the spot and at the instant. When calculations of this nature are suffered to fall in arrear, unreduced observations accumulate, and danger is incurred that the calculations are never made, and that science will lose the advantage which the observations were capable of affording.

The comparison of the barometric range in the different months at Toronto and Prague exhibits a very satisfactory accordance, and shows how similar are the phænomena which present themselves in this respect over the two continents.

The comparison of the range of the vapour pressure at Prague and Toronto exhibits only such differences as may be reasonably ascribable to the greater range of the temperature at Toronto, and possibly to the greater facility with which the air can acquire vapour at that station from the great lakes in its vicinity.

It may be worthy of notice, that the highest and lowest barometric observations in the two years at Toronto occurred within a very few days' interval of each other, being apparently parts of one great atmospheric wave.

The highest and lowest barometric observations at Prague also took place within a few days of each other, and at the same season, viz. midwinter, but a year earlier. The observations were as follows, viz.—

Extreme Range of Barometer in 1840, 1841.

	Toronto.		Prague.	
Max.	Dec. 22, 1841	30·417	Dec. 27, 1840	30·260
Min.	Dec. 4, 1841	28·672	Jan. 4, 1841	28·654
	Interval 18 days. . . .	1·745	Interval 9 days	1·606

We have undoubtedly made a considerable step in advance in meteorology, if we thus correctly substitute the consideration of the separate daily march of the pressures of the vapour and of the gaseous atmosphere, for the compara-

tively profitless study of the complex effect produced on the barometer by the operation of these two distinct agencies. The labour has been by no means small which has been bestowed in the endeavour to generalise the diurnal phænomena of the barometer by the formation of empirical formulæ; it has been in many instances the labour of highly accomplished men: but we have the recent acknowledgment of a valued and distinguished member of our own body*, who has himself engaged in this inquiry, that it failed in conducting to a recognition of the causes of the phænomena. On the other hand, the moment we apply ourselves to the contemplation of the separate phænomena of the vapour and of the air, there appears to be revealed to us a simple and beautiful dependence of each upon the diurnal march of the temperature, producing effects which in their combination seem also to afford a full and perfect solution of the problem of the daily rise and fall of the barometric column.

It would be unjust to the meteorologists of Germany if we were not gratefully to acknowledge in how great a degree this advance in the science is to be ascribed to their writings, and especially to those of M. Dove. Their meteorological researches have been pressed with an assiduity and devotion of labour which is beyond all praise. In the consideration which we (the members of the British Association) are likely soon to be called upon to exercise, whether any and what great combined endeavours are further desirable to be made for the advancement of meteorological science, we should be indeed inexcusable if we neglected to avail ourselves of the advice, and look with becoming respect to the opinions, of men, who have spent years of untiring labour, and brought great attainments to bear, on a branch of science which has been comparatively less cultivated by ourselves.

Admitting M. Dove's views, we can easily perceive that an empirical formula, in which the diurnal oscillation of the barometer should be made to vary as a function of the latitude, could never universally represent the phænomena. The difference between an insular or littoral station, where the vapour pressure attains its maximum at 9 in the forenoon, and an interior station in the same latitude where the maximum is at 2 or 3 in the afternoon, cannot both be represented with fidelity by a formula in which this difference is not taken into the account. At stations where the maximum of vapour pressure takes place at 9 A.M., and the tension thenceforward descends until the afternoon,—(as at Trevandrum),—the range of the diurnal oscillation of the barometer will be greater, *ceteris paribus*, than when, as at Toronto, the vapour pressure progressively rises from sunrise to a maximum at 2 or 3 in the afternoon: the hours of maximum and minimum will also be somewhat modified.

The important problem of the equality or inequality of the mean pressure of the gaseous atmosphere at the level of the sea at different points on the surface of the globe, has lately begun to occupy the attention of physical philosophers in a degree which will probably tend, before many years, to its practical solution. In this labour the determinations of our co-operative observatories may perform an important part. Great care has been taken that the barometers of our colonial observatories shall speak precisely the same language as the standard barometer in the Royal Society's Apartments; and steps are now taking to ensure a similar comparison of the barometers, which, in different parts of the United States, are now observed simultaneously with Toronto by our American coadjutors; and which may hereafter, if that observatory should be continued, form a very valuable extensive basis of induction for the movements of the atmosphere over that great continent.

* Professor J. D. Forbes; Meteorological Report.

Prague and Toronto furnish the materials for an interesting comparison of their respective mean gaseous pressures. I have exhibited this comparison in the subjoined table. After the proper corrections have been applied for the reduction to an invariable scale of pressure, and of the pressure itself to a common elevation above the sea, the residual difference in the pressure is about four hundredths of an inch. This is within the amount of difference that might reasonably be expected in so indirect a comparison. The inference therefore at present must be, that no unaccounted for difference of pressure exists, or at least next to none, at these two stations in Europe and America.

	Inches.
Pressure of the dry atmosphere at Toronto	29·349
Pressure of the dry atmosphere at Prague	29·019
Difference.....	0·330
Reduction to an invariable scale of pressure....	0·017
True difference of pressure.....	0·313
Difference of elevation equivalent to.....	0·273
Difference of pressure unaccounted for	0·04

Modern researches have shown that the height of the barometer at different points of the earth's surface is not only disturbed by self-adjusting causes which produce temporary displacements, but that there are causes in action which effect persistent differences in the mean height of the barometer in different localities, strictly at the level of the sea; so that, to use the words of Bessel, the mean atmospheric pressure depends on the geographical co-ordinates of a station in latitude and longitude as well as in elevation. This remark of Bessel's is founded chiefly on Erman's observations*; and Erman himself, who has considered the effect of the vapour pressure upon his barometrical heights, concludes that the pressures which the air would have exerted without the presence of aqueous vapour, indicate also persistent differences of mean gaseous pressure depending on geographical position. The instance quoted by Professor Forbes from Captain King†, who found the mean height of the barometer 29·462 in observations repeated five times a day in five consecutive months of summer at Port Famine, is an example of an atmospheric valley, as it has been called, in the former sense, but not in the latter. When allowance is made for the probable vapour pressure, the gaseous pressure at Port Famine will be found greater than its ordinary amount at the Equator; where indeed other observations have indicated a gaseous pressure lower than in the adjacent extra-tropical latitudes.

Assumed equatorial barometer.....	29·95
Deduct vapour pressure (assumed dew point 74°).....	0·83
Mean pressure of the gaseous atmosphere at the Equator	29·12
Barometer at Port Famine in five summer months.....	29·462
Deduct vapour pressure (assumed dew point 38°).....	·230
Pressure of the gaseous atmosphere at Port Famine	29·23‡

* Erman, Met. Beob. bei einer Seereise um die Erde.

† Forbes, Reports of the Brit. Assoc., 1832.

‡ This is of course only an approximate comparison; to render it more exact, it would be

In these last remarks I have perhaps ventured further from the strict subject of this communication than I should have been disposed to have done, had I not had in view to call the attention of the Section to what it is in the power of our own country to accomplish, with its widely extended dominions, in the solution of this great problem of the uniformity or otherwise of the mean pressure of the atmosphere, by the establishment of colonial observatories, conducted on a systematic plan, and continuing in operation only until certain specified and definite objects should be attained; such, for example, as the mean values, and the periodical variations, of the several meteorological elements. The present communication is an evidence of the important results which even a very brief duration of such observations may be sufficient to accomplish. When such establishments are proposed, with the sanction and support of the colonial authorities, and with the advantage of men of assured competency to conduct them, we may venture to promise the fullest co-operative aid (that may be compatible with circumstances) on the part of the British Association, which has placed foremost amongst its objects "to give a stronger impulse, and a more *systematic direction* to scientific inquiry."

I have one more point to bring under your notice; a point highly interesting in itself, and completing the evidence of the harmony in the meteorological variations.

It has been noticed that from the diminution of the gaseous pressure as the temperature of the day increases, evidencing an ascending current, we should be prepared to expect a corresponding influx of air at the station, or a diurnal variation in the force of the wind (taken without reference to the direction from which it blows), which should have its minimum at or near the coldest hour of the day, and its maximum at or near the warmest, and its progression in harmony with the curve of temperature, having one ascending and one descending branch. Such is the fact. The subjoined table exhibits the sum of the pressures, expressed in pounds avoirdupois, exerted on a square foot of surface at Toronto, at each of the observation hours in 1841, and the same in 1842. The wind is proverbially uncertain, and our means of measuring its pressure are more imperfect than we could desire; but these numbers afford an ample evidence that there is a diurnal variation in the force of the wind, and furnish a curve which, when projected, is found in remarkable correspondence with the curve of the temperature. This fact, observed at Birmingham by Mr. Osler, has been already brought under the notice of the Association at a former meeting. The diurnal march of the gaseous atmosphere furnishes the additional link in the chain of evidence, by which the connexion between the temperature (producing an ascending current) and the force of the wind (flowing in to replace it) may receive its explanation; placing before us in an intelligible form their mutual relations to each other, as cause and effect.

necessary to regard the influence of the season of the year (summer) at which the barometer was observed at Port Famine; as well as the correction due to the effect of the variation of gravity on the standard of measure. Both corrections would tend to increase the mean pressure of the gaseous atmosphere at Port Famine in comparison with that at the Equator. The barometrical observations made in the Erebus, in the late Antarctic Expedition, furnish a beautiful illustration of the progressive decrease in the height of the barometer from the tropics to the high latitudes, coincident with the diminution of the elastic force of the vapour accompanying the decrease of temperature. I hope that Sir James Ross will shortly publish these interesting observations, with the corresponding pressures of the gaseous atmosphere in the different parallels.

Sum of the pressures exerted by the force of the wind at Toronto on a surface of one foot square at the several observation hours in 1841, 1842.

	6 A.M.	8A.M.	A.M.	Noon.	2 P.M.	4P.M.	P.M.	8P.M.	10 P.M.	Mid.	2 A.M.	4A.M.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1841...	96	164	168	186	204	169	120	109	121	111	103	101
1842...	126	156	201	238	285	256	181	123	113	112	128	143
Mean	111	160	184	212	244	212	150	116	117	112	116	122

Without ascribing anything like precision to the numbers in this table (which are however likely to be more correct in relative than in absolute value), they lead to the inference that the pressure of the wind, on the average of the whole year, is doubled, or nearly so, between the coldest and warmest hours of the day; *i. e.* between 6 A.M. and 2 P.M. The confirmation, or otherwise, of this remarkable result by the observations of succeeding years cannot fail to be a point of much interest. It appears from the registry of Mr. Osler's anemometer, during four years at Birmingham, that at that station the increase in the pressure of the wind is considerably more than double between the hours of the minimum and maximum temperature. It will influence many reasonings if it shall be found as a fact of pretty general occurrence, that so large a portion of the daily wind is put in circulation to supply an ascending current*.

Synopsis of the Diurnal Variations at Toronto.

Observation hour.	Temperature.	Vapour pressure.	Gaseous pressure.	Force of wind.
	°	in.	in.	lbs.
2 A.M.....	39·8	·238	29·362	116
4 A.M.....	39·2 Min.	·234 Min.	29·368	122
6 A.M.....	39·4	·242	29·376 Max.	111 Min.
8 A.M.....	42·6	·260	29·372	160
10 A.M.	46·3	·270	29·364	184
Noon	48·9	·281	29·333	212
2 P.M.	50·5 } Max.	·285 Max.	29·309 Min.	244 Max.
4 P.M.	50·5 } Max.	·279	29·311	212
6 P.M.	48·1	·268	29·328	150
8 P.M.	44·1	·257	29·348	116
10 P.M.	42·1	·249	29·359	117
Midnight	40·8	·243	29·358	112

* To the agency of this current we should probably ascribe the upward conveyance of the vapour of increasing constituent temperature as the warmth of the day increases, and which appears to take place more rapidly than the vapour might of itself make its way if the air were tranquil. M. Kreil remarks (Mag. und Met. Beob. Erster Jahrgang, p. 140), that in the summer months, when from the increased amount of the vapour its effects are more noticeable, the clearness of the sky decreases from the commencement of the morning to about noon, and then increases uninterruptedly till towards midnight. And M. Dove notices (Met. Untersuchungen, p. 53), that on fine calm days, when there is little lateral wind to disturb the ascending current, the clear morning becomes clouded towards noon; whilst towards evening, when the ascending current has ceased, these condensed vapours, no longer upborne by its influence, descend into the warmer strata and are redissolved: hence the peculiar transparency and beauty often observed in evening views.

Synopsis of the Annual Variations at Toronto.

Month.	Temperature.	Vapour pressure.	Gaseous pressure.
	°	in.	in.
January	26·7	·132	29·454
February.....	25·6 Min.	·123 Min.	29·396
March.....	32·1	·146	29·501 Max.
April	41·6	·186	29·398
May	50·5	·241	29·324
June	61·3	·399	29·165 Min.
July	65·1 } Max.	·443	29·194
August	65·1 }	·486 Max.	29·219
September	58·5	·402	29·232
October	43·3	·232	29·407
November	35·5	·179	29·413
December	27·3	·138	29·488

The Plates which are annexed exhibit—Plate I. the *Diurnal variation*, projected in curves, of the temperature, tension of vapour, gaseous pressure, and force of the wind. In each case the whole variation, *i. e.* the difference between the highest and lowest observation in the twenty-four hours, has been made equal to $1\frac{1}{2}$ inch, and the proportionate amount has been laid off at each hour of observation: the scales are of course wholly arbitrary.

Plate II. The *Annual variation*, projected in curves, of the temperature, tension of vapour, and gaseous pressure. The whole variation of each has here also been made equal to $1\frac{1}{2}$ inch, without reference to absolute values or to the scales employed in projecting the diurnal variations.

Plate III. represents, on a scale of four inches to one-tenth of an inch, the diurnal variations of the barometer and gaseous pressure, projected in curves, and connected at each observation hour by vertical lines proportioned to the elastic force of the vapour. This Plate is illustrative of the conversion of the single progression of the gaseous pressure, into the double progression of the barometric pressure, by the presence and influence of the vapour pressure. The detached curve is that of the diurnal march of the temperature, and is inverted, for the purpose of showing more distinctly its correspondence with the curve of gaseous pressure.

An inference of much practical utility to general observers may be drawn from meteorological observations, made with the frequency which can only be expected at those observatories, where a sufficient establishment is maintained for the express purpose of observation. We may find that comparatively a very few observations in each day, at hours not inconvenient in ordinary life, may furnish a very close approximation to the mean values and to the annual and diurnal march of the atmospherical phænomena. Thus from the complete record at Toronto we find, as shown in the subjoined table, that the mean values of the temperature, of the vapour tension and of the humidity, of the pressure of the gaseous atmosphere, and of the whole atmospheric pressure, may all be obtained, with a very near approximation, by a single observation at 8 P.M. (mean time), provided the observation be made with tolerable precision in regard to the hour. By combining with this an observation about sunrise, and another between 2 and 4 in the afternoon, the maximum and minimum of the temperature, of the aqueous and gaseous pressure, and of the humidity, may also be obtained. These hours are by no means inconvenient for persons whose avocations permit them to keep a register at all; and appear in every way preferable to a selection which makes 3 o'clock in the morning one of the observation hours. That hour is perhaps the most generally inconvenient for the purpose of the whole twenty-four. The hours here suggested must not however be understood to be of universal application: they are not so thoroughly suitable, for example, at stations where, as at Trevandrum, the vapour pressure attains a maximum in the forenoon.

Convenient hours of observation.

For mean values, 8 P.M. mean time (precise); which at Toronto gives the following approximation: viz.—

At 8 P.M. at Toronto.	Temperature	44°·1	Mean annual value		44°·4
	Humidity	78·5	,,	,,	78·0
	Vapour tension	·257	,,	,,	·259
	Barometric pressure	29·605	,,	,,	29·608
	Gaseous pressure	29·345	,,	,,	29·349

For maxima and minima.

From 4 to 6 A.M., for minimum of temperature and tension of vapour, and for maximum of humidity and gaseous pressure.

From 2 to 4 P.M., for maximum of temperature and tension of vapour, and for minimum of humidity and gaseous pressure.

I have now only to apologize to the Section for the length of time that I have occupied them, and to thank them for their patient attention.

York, September 27th, 1844.

Postscript, Woolwich, Nov. 30.

After the preceding pages were printed, I received from Mr. Airy the volume of the Greenwich magnetical and meteorological observations for 1842, in which the meteorological reductions have been made in almost exactly the same form as those of Toronto. The volume was accompanied by a suggestion from the Astronomer Royal, that it might increase the interest of this communication, if I were to add a few words by way of appendix, showing the points of similarity or dissimilarity in the results at the two stations. I have much pleasure in adopting this suggestion, and in availing myself of Mr. Airy's permission to do so; for I have had great satisfaction in noticing the very remarkable similarity which prevails in the results at Greenwich and Toronto, with reference to several points which have been the objects of especial notice in the preceding discussion. In the diurnal variations of the elastic force of the vapour,—of the gaseous pressure,—and of the force of the wind,—the evidence of a direct dependence on the diurnal march of the temperature is fully as striking at Greenwich as at Toronto, as will be seen by the following synopsis:

Synopsis of the Diurnal Variations at Greenwich.

Observation hours.	Barometer.	Thermometer.	Vapour pressure.	Gaseous pressure.	Force of the wind.
h m	in.	°	in.	in.	Sums of the estimated forces.
1 20 A.M.	29·826	45·4	·307	29·519	97½
3 20 A.M.	·822	44·9 Min.	·302 Min.	·520 Max.	93½
5 20 A.M.	·824	45·0	·307	·517	89½
7 20 A.M.	·835	47·2	·321	·514	89 Min.
9 20 A.M.	·846	51·0	·335	·511	106½
11 20 A.M.	·845	54·1	·347	·498	117¼
1 20 P.M.	·832	55·7 Max.	·349 Max.	·483	131¼ Max.
3 20 P.M.	·823	55·0	·348	·475 Min.	129
5 20 P.M.	·823	52·8	·338	·485	120¾
7 20 P.M.	·830	49·8	·330	·500	109¾
9 20 P.M.	·838	47·8	·321	·517	102
11 20 P.M.	·836	46·3	·315	·521 Max.	95
Means of the Year.	29·832	49·6	·326	29·506	

At Greenwich the force of the wind is estimated at each observation hour in numbers varying within the limits of 0 to 6. At Toronto the estimation is in lbs. pressure on a square foot of surface kept perpendicular to the current. In single instances the scales are comparable, because the square of the number expressing the force at Greenwich corresponds approximately to the pressure in lbs. avoirdupois. But the comparability of the scales does not hold good when the sums of the forces and the sums of the pressures are taken. The sums of each are however comparable *inter se*, and show the hours of maximum and minimum force, and the regularity of the progression. The registry of the anemometer at Greenwich shows that the pressure of the wind is more than doubled in its mean diurnal range.

The following table exhibits the differences at the several observation hours of Greenwich and Toronto, of the temperature, of the vapour pressure, and of the gaseous pressure, from their respective mean yearly values. The sign + signifies above the mean value of the year, and — below it.

Observation hour.		Temperature.		Vapour pressure.		Gaseous pressure.	
Greenwich.	Toronto.	Greenwich.	Toronto.	Greenwich.	Toronto.	Greenwich.	Toronto.
h. m.	h.	°	°	in.	in.	in.	in.
1 20 A.M.	2 A.M.	−4·2	−4·6	−·019	−·021	+·013	+·013
3 20 A.M.	4 A.M.	−4·7	−5·2	−·024	−·025	+·014	+·019
5 20 A.M.	6 A.M.	−4·6	−5·0	−·019	−·017	+·011	+·027
7 20 A.M.	8 A.M.	−2·4	−1·8	−·005	+·001	+·008	+·023
9 20 A.M.	10 A.M.	+1·4	+1·9	+·009	+·011	+·005	+·015
11 20 A.M.	Noon.	+4·5	+4·5	+·021	+·023	−·008	−·017
1 20 P.M.	2 P.M.	+6·1	+6·1	+·023	+·026	−·023	−·040
3 20 P.M.	4 P.M.	+5·4	+6·1	+·022	+·021	−·031	−·039
5 20 P.M.	6 P.M.	+3·2	+3·7	+·012	+·010	−·021	−·022
7 20 P.M.	8 P.M.	+0·2	−0·3	+·004	−·002	−·006	−·001
9 20 P.M.	10 P.M.	−1·8	−2·3	−·005	−·009	+·001	+·009
11 20 P.M.	Midnight.	−3·3	−3·6	−·011	−·016	+·015	+·009

The mean *monthly* values of the vapour pressure, and of the gaseous pressure at Greenwich exhibit also the same correspondence with the variation of the temperature in the different months of the year as at Toronto.

Synopsis of the Annual Variation of the Temperature, Vapour pressure, and Gaseous pressure at Greenwich.

Month.	Temperature.	Vapour pressure.	Gaseous pressure.	Vapour pressure + or −, *i. e.* greater or less, than the mean annual pressure.	Gaseous pressure or −, *i. e.* greater or less than the mean annual pressure.
	°	in.	in.	in.	in.
January ...	32·9 Min.	·186 Min.	29·715 Max.	−·140	+·209
February...	40·8	·250	·626	−·076	+·120
March.....	44·9	·272	·475	−·054	−·031
April	45·2	·248	·606	−·078	+·160
May	53·2	·334	·448	+·008	−·058
June	62·9	·433	·468	+·107	−·038
July	60·2	·416	·404	+·179	−·102
August ...	65·4 Max.	·505 Max.	·364	+·095	−·142
September.	56·4	·421	·294 Min.	−·038	−·212
October ...	45·4	·288	·561	−·058	+·055
November.	42·8	·268	·331	−·031	−·175
December .	45·0	·295	·712	.....	+·206
Mean of the Year.	49·6	·326	29·506		

It appears therefore that the annual and diurnal variations derived from the observations at Greenwich present a most satisfactory accordance with those at Toronto in those points which were brought most prominently before the Association at York, and to which the attention of the Section was especially called, viz.—

First, in regard to the diurnal variation:

1. The vapour tension and the force of the wind have each a minimum, and the gaseous pressure a maximum, at or near the coldest hour of the day.

2. The vapour tension and the force of the wind have each a maximum, and the gaseous pressure a minimum, at or near the warmest hour of the day.

3. The diurnal march of each from the minimum to the maximum, and from the maximum to the minimum again, is continuous, like that of the temperature, without any interruption deserving of the name.

4. At Greenwich as well as at Toronto the diurnal variations of the vapour tension and of the gaseous pressure, produce by their combination the double maxima and minima of the diurnal oscillation of the mercury in the barometer.

Secondly, in respect to the annual variation:

The annual march is somewhat less regular at Greenwich than at Toronto, being derived from the observations of a single year only; but we have the same general features: a minimum of temperature and vapour-pressure, and a maximum of gaseous pressure in the midwinter; and a maximum of temperature and vapour pressure, and a minimum of gaseous pressure in the midsummer. All the summer months are characterised by the + sign in the vapour, and by the − in the gaseous pressure; and all the winter months by the − sign in the vapour, and the + sign in the gaseous pressure.

I am unable at the present moment to pursue the comparison of the Greenwich and Toronto results in many other points in which I can perceive that the interest would prove an ample repayment for the time so employed. But I may hope to enjoy some future occasion of resuming the subject under more favourable circumstances in respect to leisure than I can at present command.

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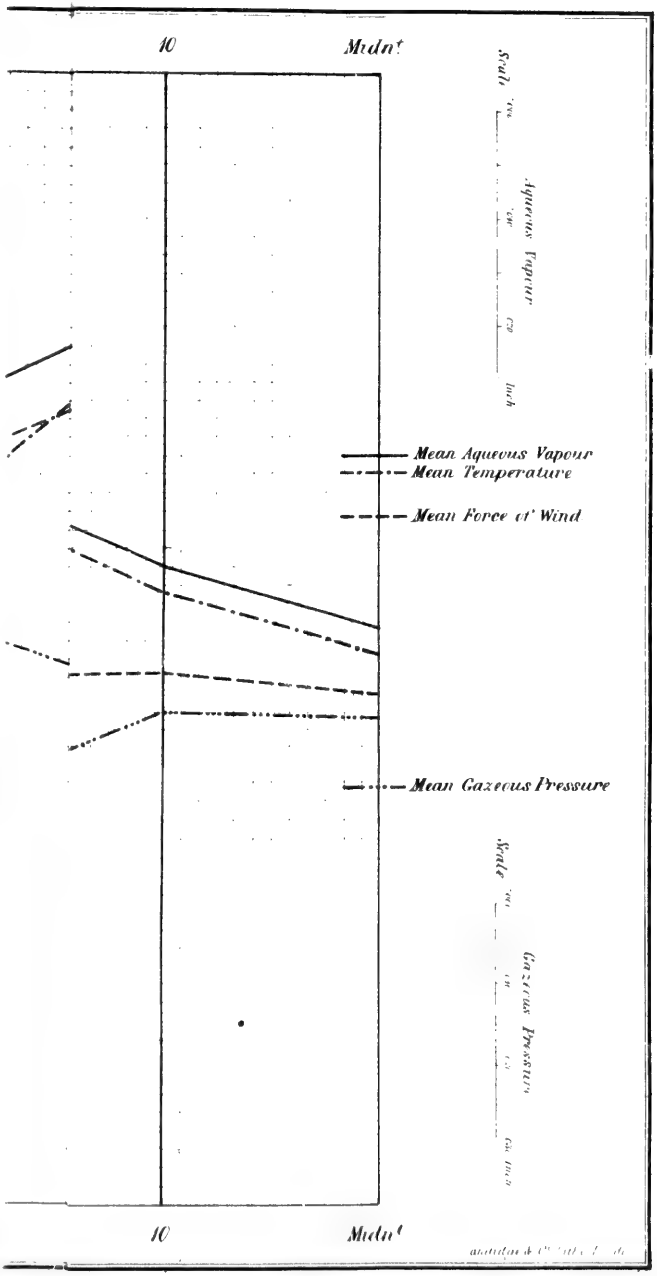
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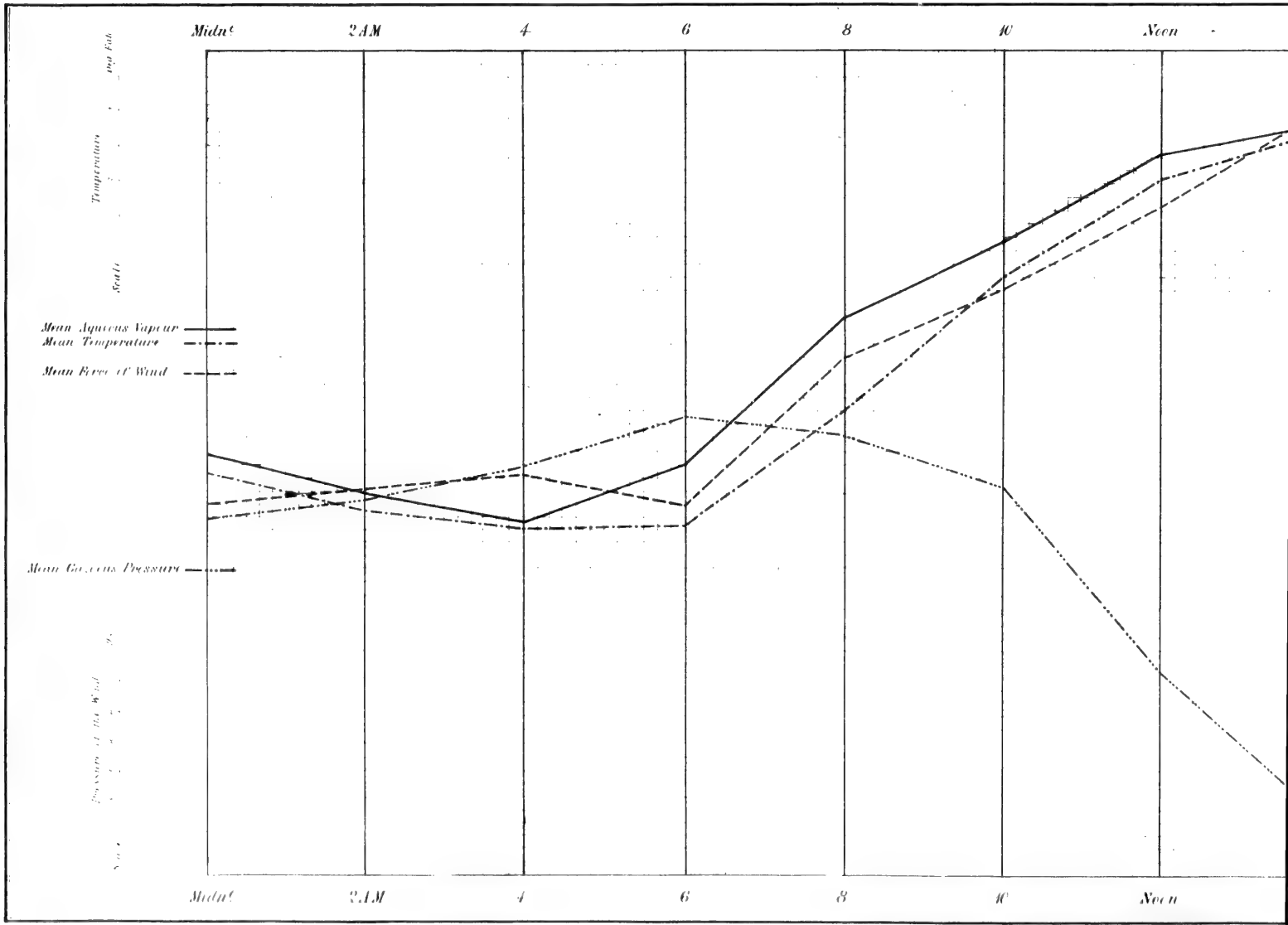
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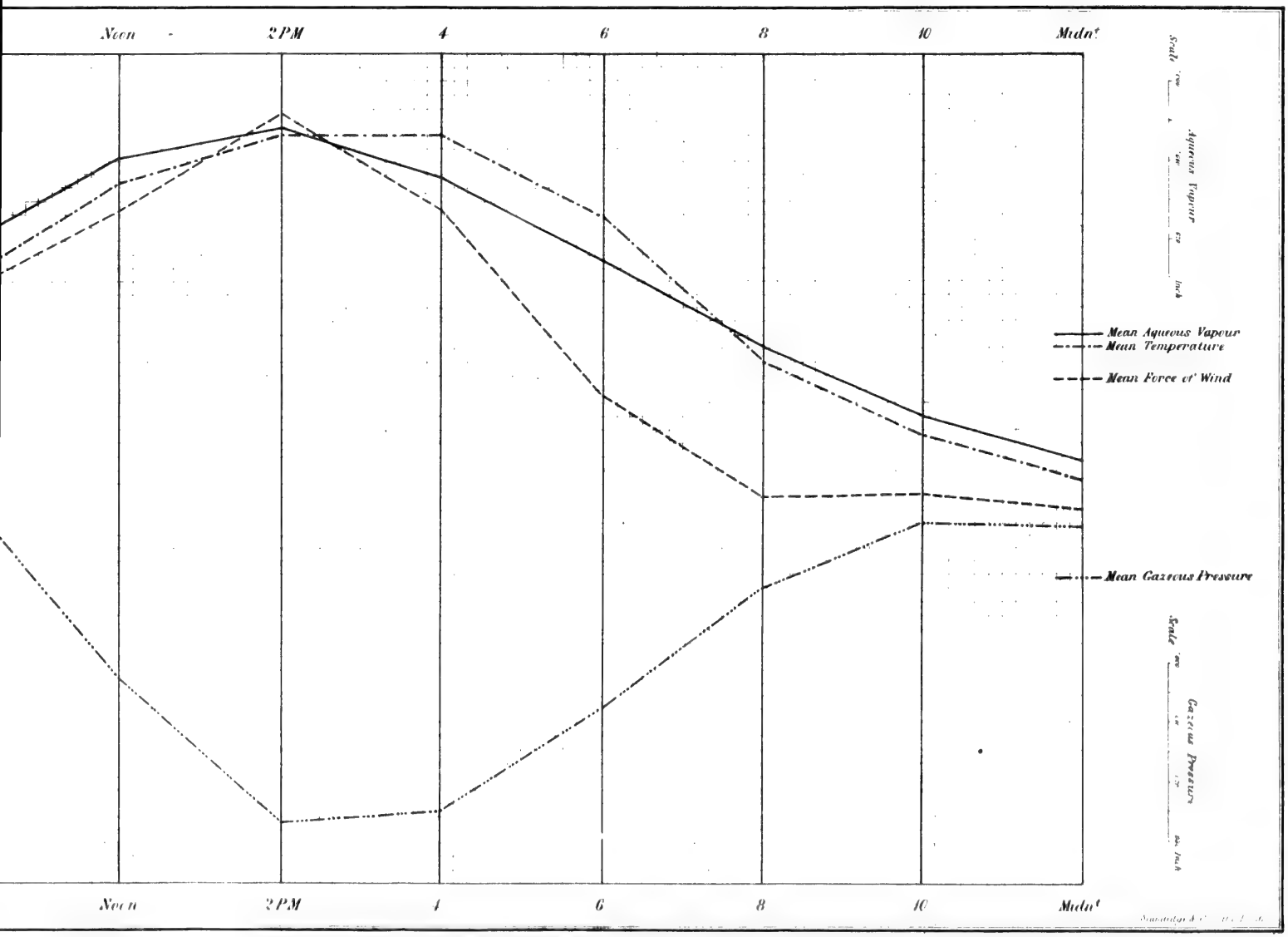
ure — *The Pressure of the Aqueous Vapour*
he Wind — *The Pressure of the Gazeous Atmosphere* } *at Toronto.*



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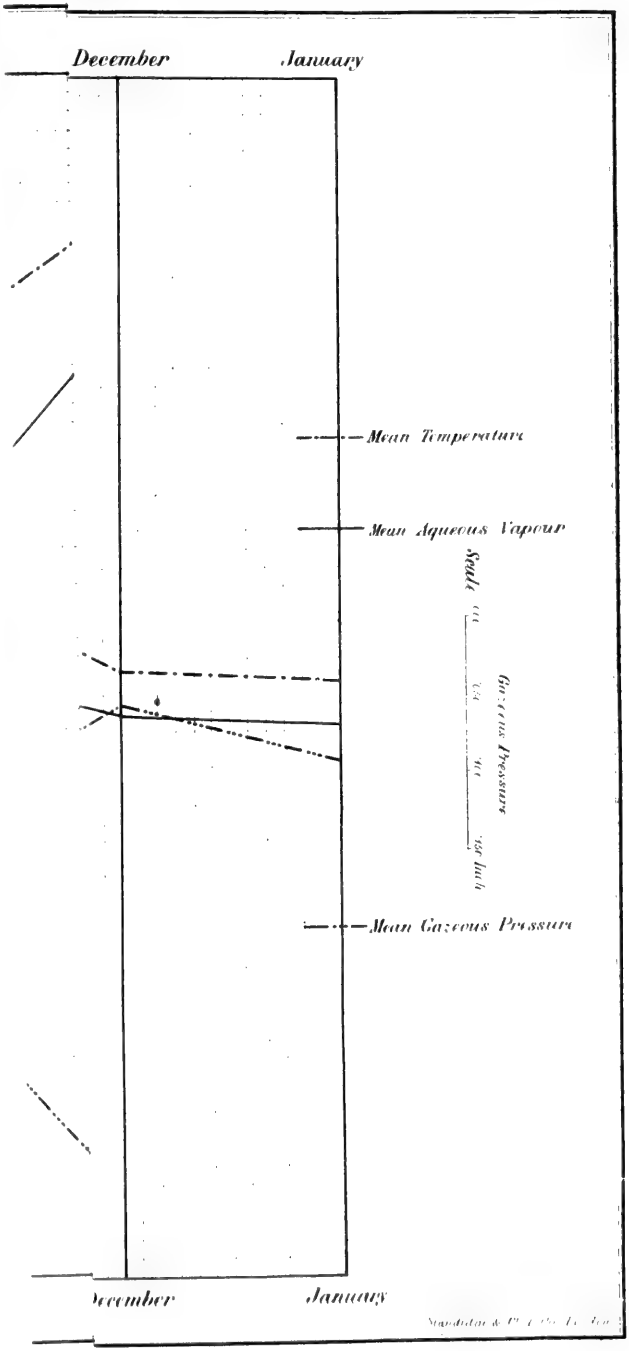
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Mean Temperature
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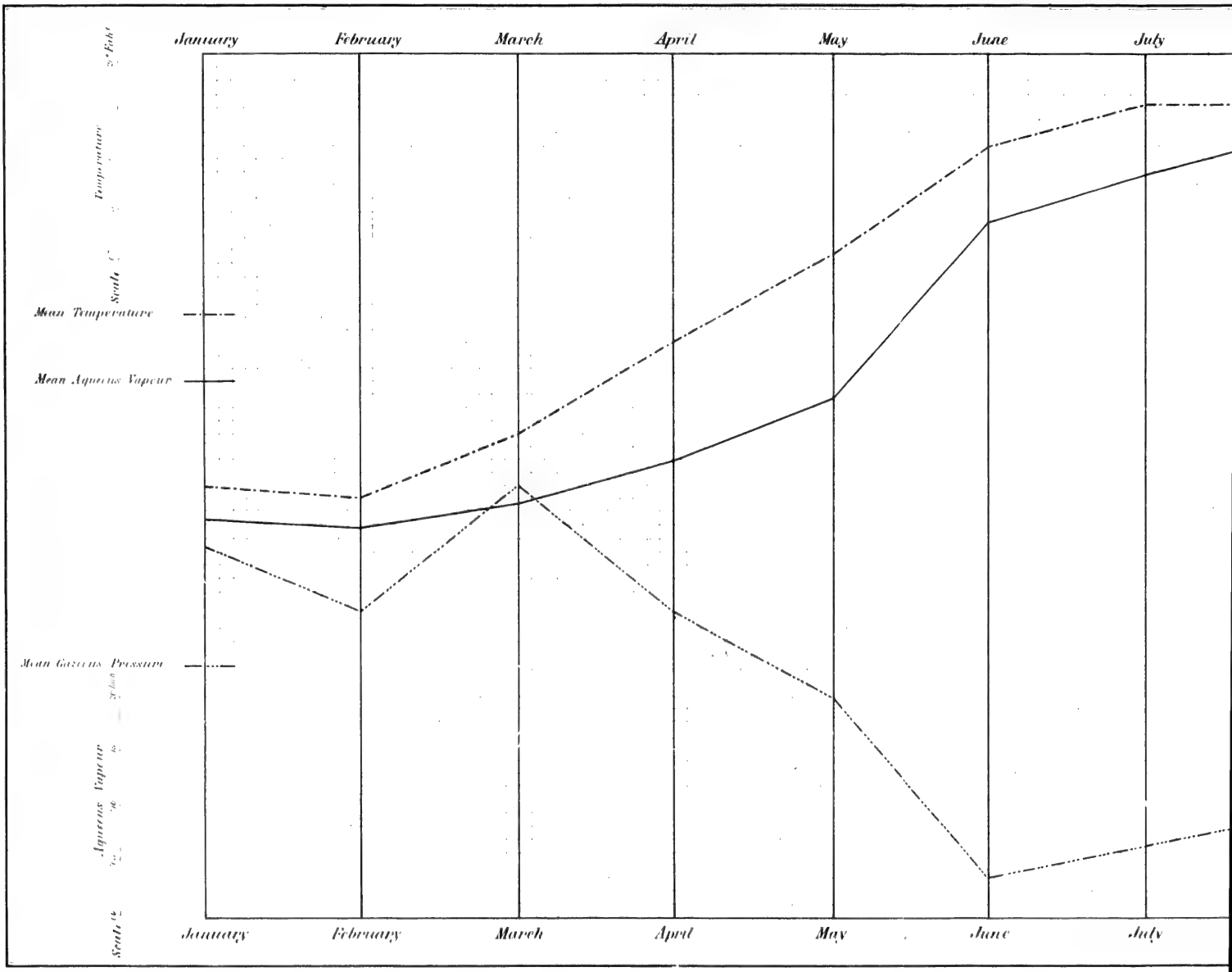
Mean Gaseous Pressure
December
January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Aqueous Vapour
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— the Pressure of the Aqueous Vapour, — · — · — · — the Pressure of the Gazeous Atmosphere, at Toronto.

Mean of Two Years.

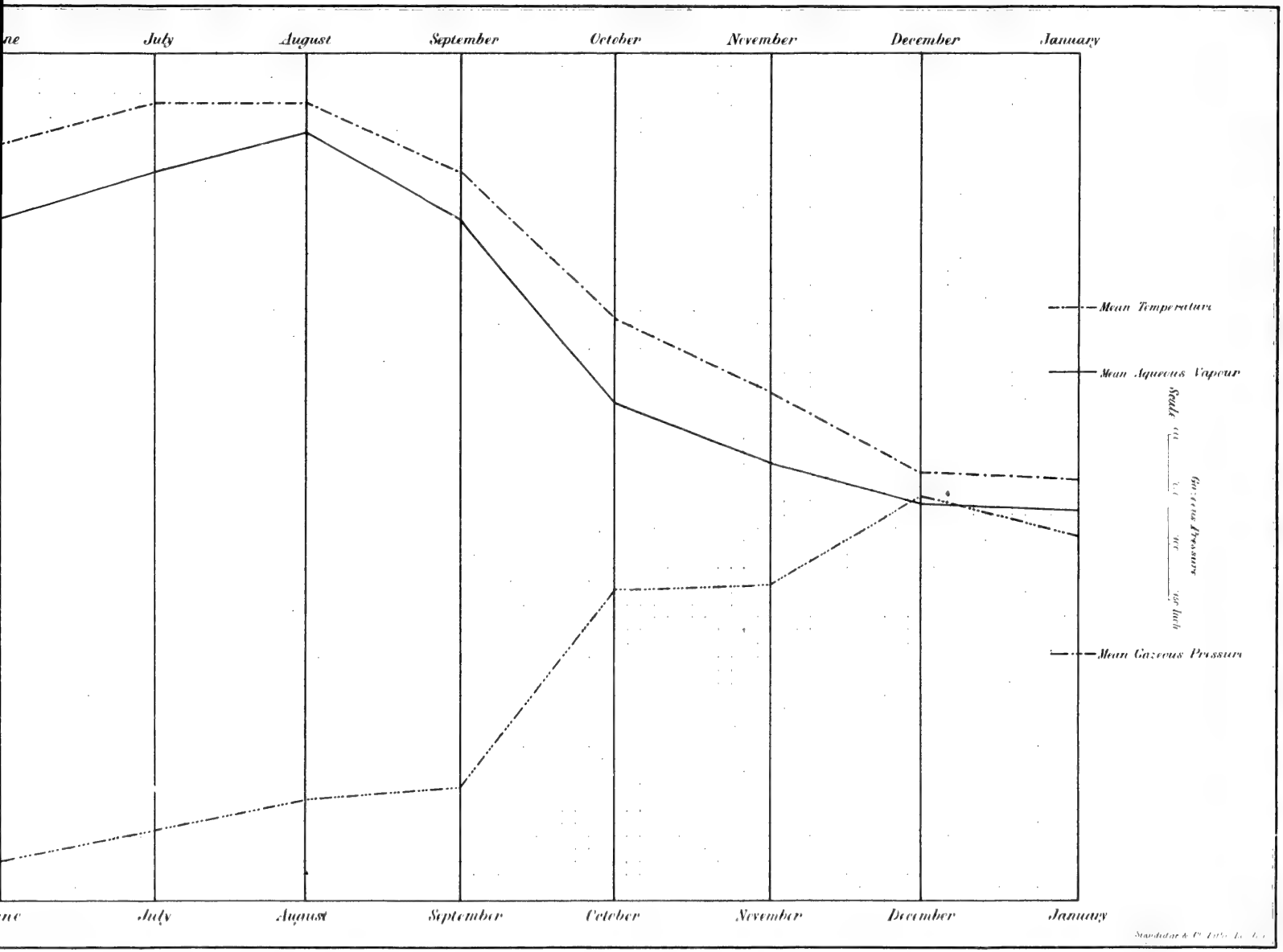
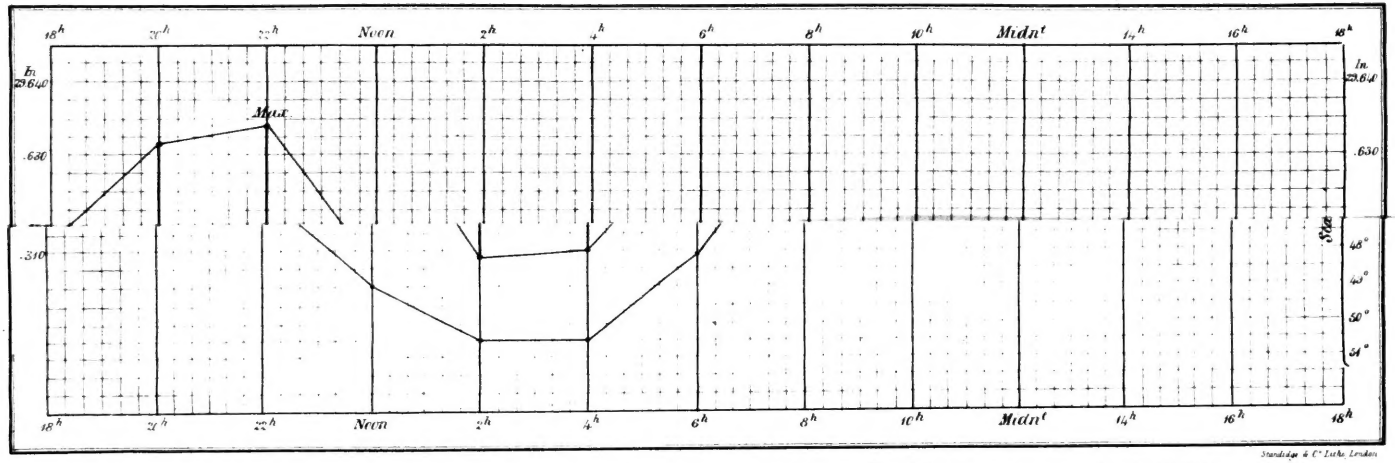


Plate illustrating the correspondence between the diurnal variations of the Temperature and of the Gazeous portion of the Atmosphere and

Plate illustrating the correspondence between the diurnal variations of the Temperature and of the Gazeous portion of the Atmosphere and the double progression of the Barometric pressure when the elastic force of the Vapour is superadded to the Gazeous Pressure.



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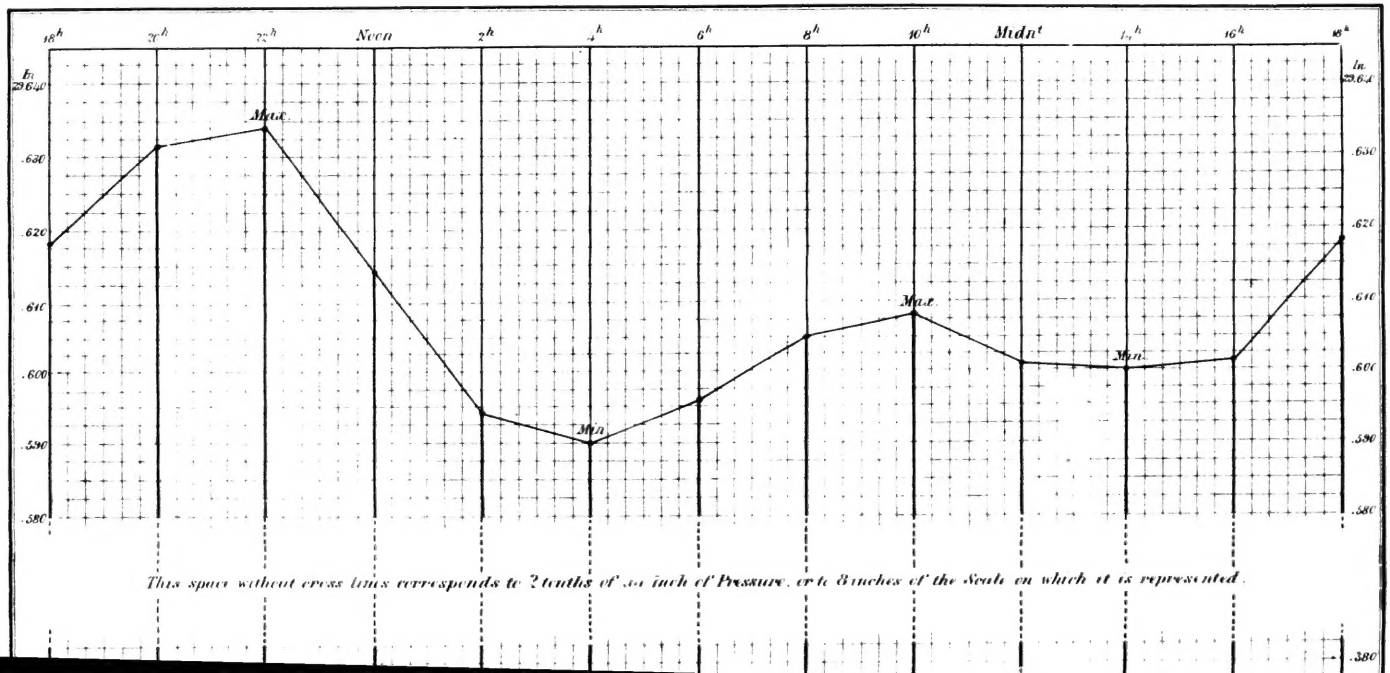
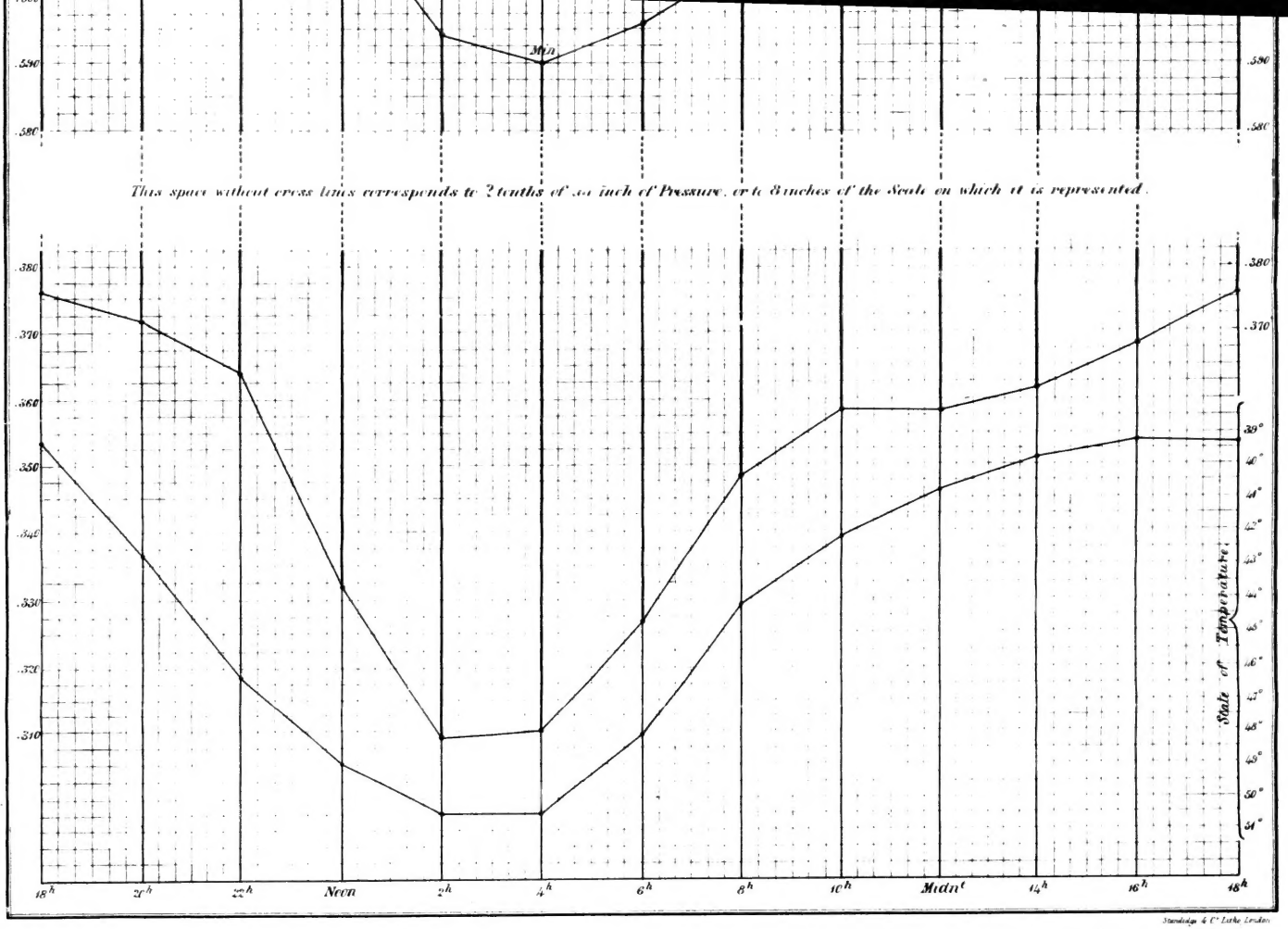
The upper Curve shews the Pressure indicated by the Barometer. the lines connecting the upper & middle Curves represent the elastic force of the Vapour. the dotted portion of each of these lines corresponds to ·2 of Vapour Pressure (or eight inches of the Scale on which the pressures are represented). the middle Curve denotes the residual pressure after the elastic force of the Vapour has been taken from the Barometric Pressure. the detached Curve below represents the Temperature, and is inverted to shew the correspondence between the Curves of Temperature and Gazeous Pressure.

Plate illustrating the correspondence between the diurnal variations of the Temperature and of the Gaseous portion of the Atmosphere and the double progression of the Barometric pressure when the elastic force of the Vapour is superadded to the Gaseous Pressure.





The upper Curve shews the Pressure indicated by the Barometer. the lines connecting the upper & middle Curves represent the elastic force of the Vapour. the dotted portion of each of these lines corresponds to 2 of Vapour Pressure (or eight inches of the Scale on which the pressures are represented); the middle Curve denotes the residual pressure after the elastic force of the Vapour has been taken from the Barometric Pressure. the detached Curve below represents the Temperature, and is inverted to shew the correspondence between the Curves of Temperature and Gaseous Pressure.